STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL AND GEOPHYSICAL SURVEYS

Steve Cowper, *Governor*

Judith M. Brady, *Commissioner*

Robert B. Forbes, *Director and State Geologist*

June 1988

This report is a preliminary publication of DGGS. The author is solely responsible for its content and will appreciate candid comments on the accuracy of the data as well as suggestions to improve the report.

Report of Investigations 88-11

RECONNAISSANCE OF SURFACE-WATER RESOURCES IN THE HOUSTON AREA, ALASKA, 1985-86

by

E.J. Collazzi, M.A. Maurer, and S.J. Carrick

STATE OF ALASKA
Department of Natural Resources
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

According to Alaska Statute 41, the Alaska Division of Geological and Geophysical Surveys is charged with conducting 'geological and geophysical surveys to determine the potential of Alaskan land for production of metals, minerals, fuels, and geothermal resources; the locations and supplies of ground water and construction materials; the potential geologic hazards to buildings, roads, bridges, and other installations and structures; and shall conduct such other surveys and investigations as will advance knowledge of the geology of Alaska.'

In addition, the Division of Geological and Geophysical Surveys shall collect, record, evaluate, and distribute data on the quantity, quality, and location of underground, surface, and coastal water of the state; publish or have published data on the water of the state and require that the results and findings of surveys of water quality, quantity, and location be filed; require that water-well contractors file basic water and aquifer data, including but not limited to well location, estimated elevation, well-driller's logs, pumping tests, flow measurements, and water-quality determinations; accept and spend funds for the purposes of this section, AS 41.08.017 and 41.08.035, and enter into agreements with individuals, public or private agencies, communities, private industry, and state and federal agencies; collect, record, evaluate, archive, and distribute data on seismic events and engineering geology of the state; and identify and inform public officials and industry about potential seismic hazards that might affect development in the state.

Administrative functions are performed under the direction of the Director, who maintains his office in Fairbanks. The locations of DGGS offices are listed below:

- 794 University Avenue
  (Suite 200)
  Fairbanks, Alaska 99709
  (907)474-7147
- 3700 Airport Way
  Fairbanks, Alaska 99709
  (907) 451-2760
- 400 Willoughby Avenue
  (3rd floor)
  Juneau, Alaska 99801
  (907) 465-2533
- 18225 Fish Hatchery Road
  P.O. Box 772116
  Eagle River, Alaska 99577
  (907) 696-0070

This report is for sale by DGGS for $2.50. DGGS publications may be inspected at the following locations. Mail orders should be addressed to the Fairbanks office.

- 3700 Airport Way
  Fairbanks, Alaska 99709
- U.S. Geological Survey
  Public Information Office
  701 C Street
  Anchorage, Alaska 99513
- 400 Willoughby Avenue
  (3rd floor)
  Juneau, Alaska 99801
- Information Specialist
  U.S. Geological Survey
  4230 University Drive, Room 101
  Anchorage, Alaska 99508

CONTENTS

FIGURES

TABLES

RECONNAISSANCE OF SURFACE-WATER RESOURCES IN THE HOUSTON AREA, ALASKA, 1985-86

by
E.J. Collazzi, M.A. Maurer, and S.J. Carrick

INTRODUCTION

This report summarizes an investigation made by the State of Alaska Division of Geological and Geophysical Surveys (DGGS) in cooperation with the City of Houston, Alaska in 1985 and 1986. The study goals were: 1) to determine the quantity and quality of naturally-occurring surface waters in and around the City of Houston for the purpose of evaluating water supply potential; and 2) to define significant watershed areas. During this investigation, existing data on surface water in the Houston area were collected and compiled, and reconnaissance-level discharge and water-quality measurements were obtained.

Incorporated in 1966, the city of Houston occupies an area of 23-1/4 mi^2 and is located 30 air miles north of Anchorage on the George Parks Highway in southcentral Alaska (fig. 1). Within the Houston city limits, surface water consists of the Little Susitna River and several small tributaries, Meadow Creek and its tributaries, including Lucille Creek, and Zero, Bearpaw, Prator, Morvro, Loon, Cheri, Long, Twin, and Woody Lakes, as well as a few small ponds. Bench Lake, approximately 1-1/2 mi northeast of the city, was included in this study at the request of city officials.

Five sites on four unnamed tributaries to the Little Susitna River were selected for study, as were two lakes, Zero Lake and Bench Lake. In addition, existing data were compiled and summarized for the Little Susitna River and Meadow Creek, and a watershed map of the Houston area was constructed. This information will aid in evaluating the water-supply potential of Houston area surface-water sources.

HOUSTON WATERSHEDS

Watershed areas within the City of Houston were defined and mapped from aerial photographs, road maps, orthophotomaps and topographic maps. The aerial photographs (dated 1981 and 1982) were used to reconcile discrepancies between maps. Drainage divides were difficult to locate in the flat, poorly-drained area around Houston, and some may have been altered by human activities, such as road building. The maps in this report are the most accurate delineation possible without more extensive field checking. The presence of lake inlets and outlets or stream courses which were not located in the field might warrant modification of the boundaries presented here.

The Meadow Lakes are representative of hundreds of small, irregular lakes in kettle moraines around this part of the Cook Inlet, where the land surface was shaped primarily by stagnant, melting ice (Reger and Updike, 1983). Where surface drainage was disrupted, some small lakes occupy their own closed basins. North of the Little Susitna River, differential glacial erosion has created higher relief and a better-developed drainage pattern, although drainage is still complicated by postglacial surface morphology.

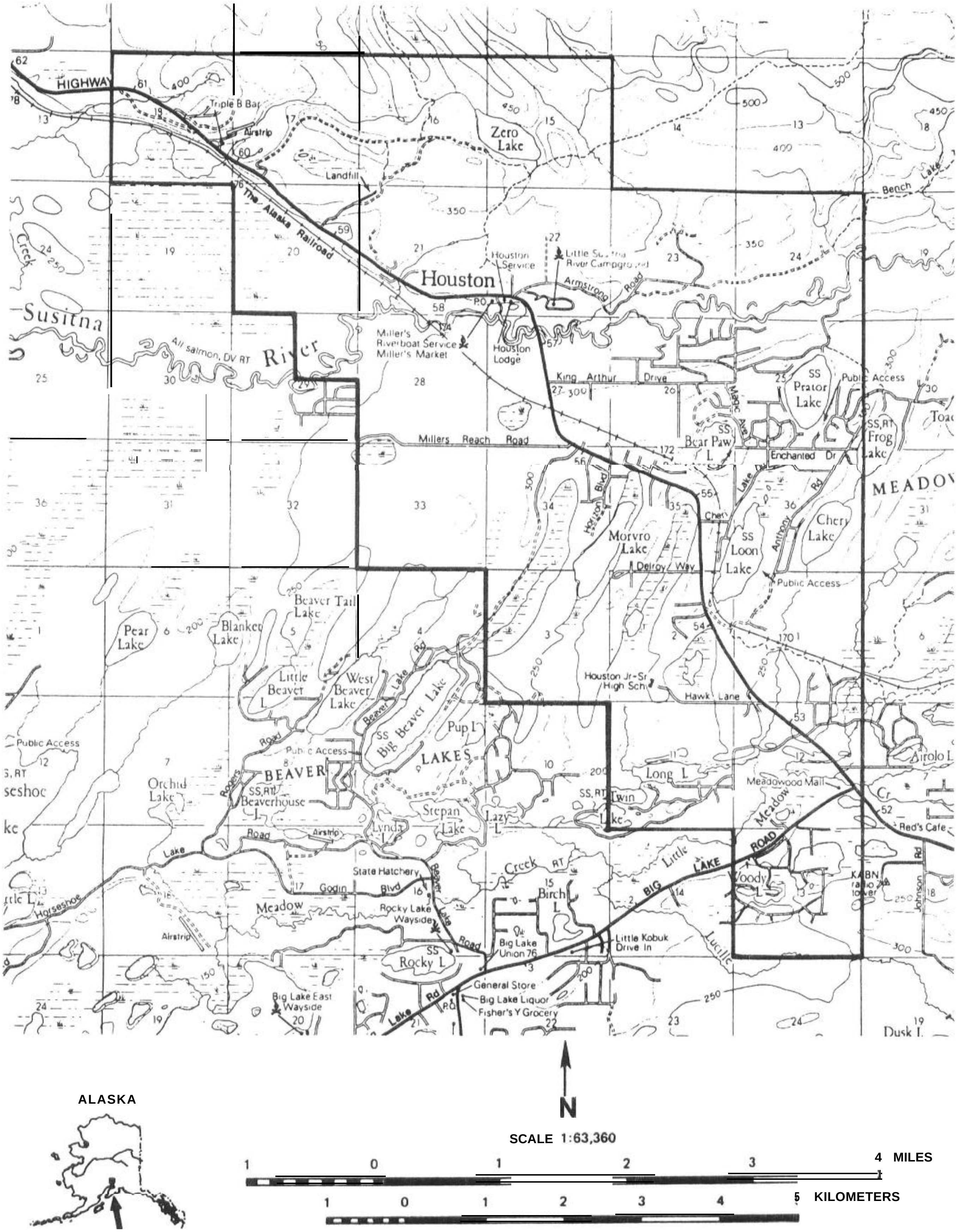


Figure 1. Location map, Houston, Alaska.

Figure 2 shows that most of the northern half of the city drains to the Little Susitna River, while most of the southern half drains to Meadow Creek.

HOUSTON STREAMFLOW

There are few long-term discharge records for streams in the Houston area. The Little Susitna River has been continuously gaged by the U.S. Geological Survey (USGS) since 1948 at a site about 20 mi upstream of the Houston city limit; partial crest-stage and discharge data also exist for a site on the river 300 ft downstream from the Parks Highway bridge within the city (fig. 3). The 36-yr record for the upper site shows an average annual discharge of 209 cubic feet per second (cfs) or 93,800 gallons per minute (gpm); the recorded extremes are 7,840 cfs (3,520,000 gpm) in August 1971 and 8 cfs (3,590 gpm) in April 1956 and March 1957 (Bigelow and others, 1985). Lowest flows historically occurred in March and April; peak flows may occur from snowmelt in June or from summer storms in July and August. A comparison of the 36-yr record at the upper site with the partial record at the lower site suggests that slightly higher values would be encountered on the Little Susitna River within the City of Houston. A summary of streamflow data for this river is given in table 1.

Partial records also exist for Meadow Creek (sometimes called Little Meadow Creek), which crosses the southern part of the city. The USGS and the Alaska Department of Fish and Game (ADFG) have taken instantaneous discharge measurements at various times at the old Parks Highway crossing within the city limit, and ADFG has measured Meadow Creek at the Blodgett Lake outlet, 1.2 mi east of the city limit (fig. 3). Measured streamflow at the highway crossing has ranged from 4.8 cfs (2,160 gpm) to 44.0 cfs (19,800 gpm), and at the lake outlet from 3.7 cfs (1,660 gpm) to 12.3 cfs (5,520 gpm) (Bigelow and others, 1985; Clupach, written commun., 1985). These measurements, which are probably not representative of the total seasonal range of flow that can be expected on this stream, are summarized in table 2.

Streamflow was evaluated by DGGS personnel at five sites on tributaries to the Little Susitna River in July and August 1985 and February and March 1986 (fig. 3). Sites 1, 2, and 5 were chosen because they drain the two lakes identified as potential water sources, while sites 3 and 4 were chosen because they appeared from the initial reconnaissance to have the best water-supply potential of the secondary streams. Site 1 is on an unnamed stream which flows out of Zero Lake about 1/4 mi below the lake outlet and 30 ft downstream of a small road culvert. Site 2 is located on the same stream about 75 ft upstream of the Parks Highway culvert at mile 60.1. Site 3 is on an unnamed stream about 50 ft downstream of the culvert at mile 0.8 Armstrong Road. Site 4 is at the footbridge on another unnamed stream at the end of Armstrong Road (mile 2.8). Site 5 is about 75 ft upstream of the Bench Lake Trail crossing on an unnamed stream that flows out of Bench Lake.

All streamflow velocity measurements were made with a Marsh-McBirney Model 201 electromagnetic current meter. An attempt was made to measure the streams during periods of highest runoff and lowest flow defined from existing data for this area. Actual peak flows, however, may exceed the values recorded. Discharge, stream-bed material, width, cross-sectional area, mean

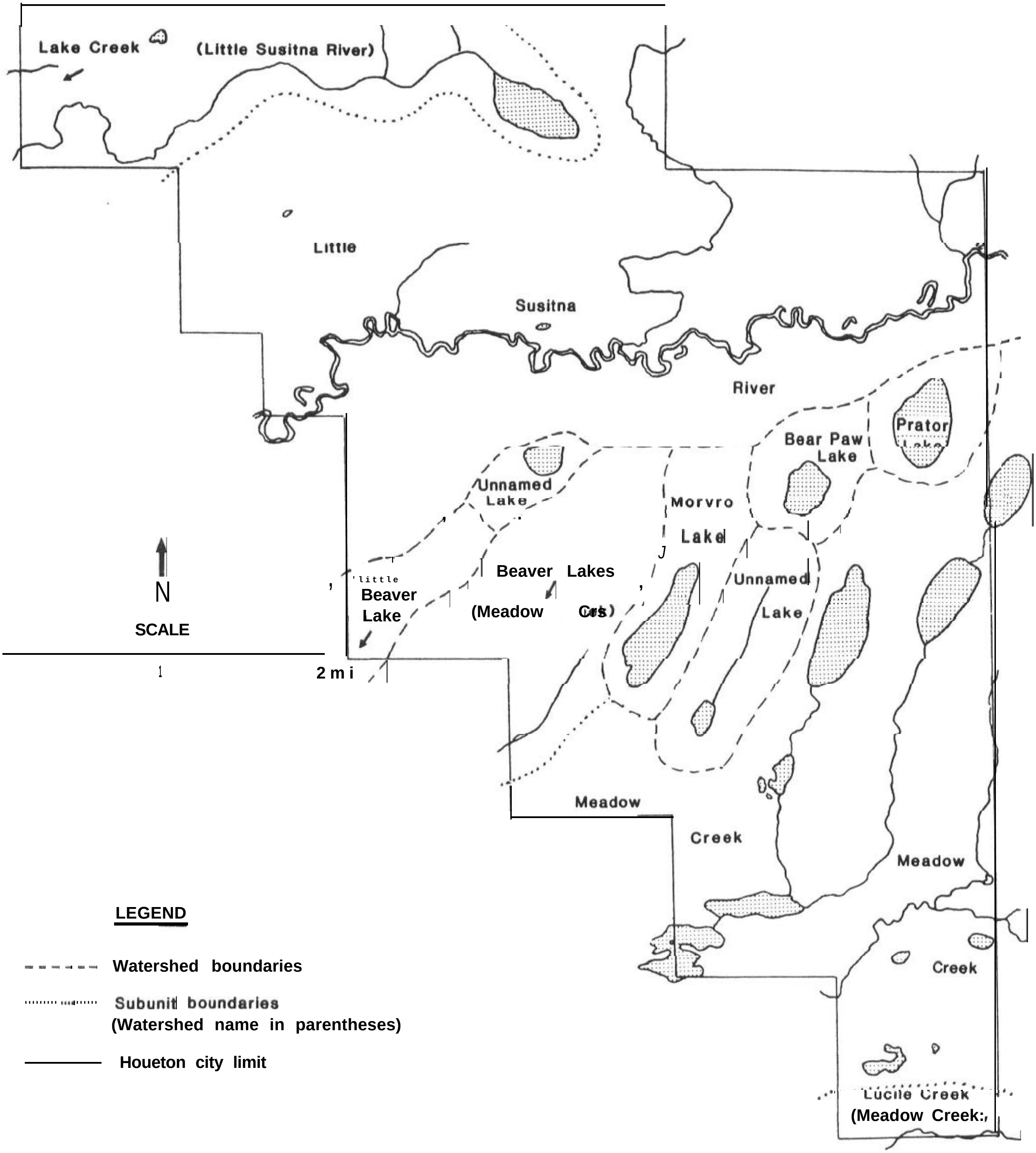


Figure 2. Watershed map of the Houston area, Alaska. Each watershed is named for its apparent drainage destination. Subunits are named for their immediate drainage destinations with main watershed name in parentheses.

Table 1. Summary of streamflow data for the Little Susitna River, Alaska.

Little Susitna River near Palmer
(USGS site no. 15290000)

Drainage area:	61.9 mi^2
Period of record:	July 1948-present
Average discharge:	36 yrs, 209 cfs (93,800 gpm)
Extremes, period of record:	Maximum, 7,840 cfs (3,520,000 gpm), 8/10/7 Minimum, 8 cfs (3,590 gpm), 4/1-20/56 & 3/11-12/57
Extremes, latest year (10/83-9/84):	Maximum, 2,830 cfs (1,271,000 gpm), 8/25/84 Minimum, 18 cfs (8,080 gpm), 4/26/84
Average discharge, latest year (10/83-9/84):	245 cfs (110,000 gpm)
Daily discharge data:	Can be found in the U.S. Geological Survey report, Water Resources Data for Alaska, published annually.

Little Susitna River near Houston
(USGS site no. 115290100)

Drainage area:	168 mi^2
Period of record:	No continuous records; miscellaneous measurements 1978-1984
Average discharge:	n.a.
Extremes measured:	Maximum, 3,200 cfs (1,437,000 gpm), 9/16/80 Minimum, 47 cfs (21,100 gpm), 3/15/78

Summary of discharge measurements:

Date	Discharge (cfs)	Discharge (gpm)
03/15/78	47	21,100
05/19/78	226	101,000
07/06/78	496	223,000
07/31/78	480	216,000
08/22/78	377	169,000
09/20/78	208	93,400
09/16/80	3,200	1,437,000
10/15/80	352	158,000
03/02/81	68	30,500
06/23/81	315	141,000
07/11/81	2,070	930,000
07/14/81	1,140	512,000
03/02/83	63	28,300
05/04/83	344	154,000
07/27/83	291	131,000
07/05/84	478	215,000
08/25/84	1,210	543,000
08/26/84	2,170	974,000
08/27/84	1,200	539,000

Table 2. Summary of streamflow data for Meadow Creek, Alaska.

Meadow Creek at Parks Highway crossing
(USGS site no. 15286550)

Drainage area: 17 mi^2

Period of record: No continuous records; miscellaneous measurements 1959-1983[a]

Average discharge: n.a.

Extremes measured: Maximum, 44 cfs (19,800 gpm), 10/12/72
Minimum, 4.8 cfs (2,160 gpm), 3/24/76

Summary of discharge measurements:

Date	Discharge (cfs)	Discharge (gpm)
08/15/59	8.9	4,000
08/25/72	8.9	4,000
09/23/72	8.1	3,640
09/26/72	12.2	5,480
10/12/72	44.0	19,800
11/08/72	11.7	5,250
05/21/73	15.3	6,870
02/12/76	5.8	2,600
03/24/76	4.8	2,160
03/11/77	5.0	2,250
03/02/81	11	4,940
06/24/81	8.5	3,820
03/10/82	8.4	3,770
03/02/83	11	4,940
07/27/83	13	5,840

Meadow Creek at Blodgett Lake outlet

Drainage area: 13 mi^2

Period of record: No continuous records; miscellaneous measurements 1972-1973[b]

Average discharge: n.a.

Extremes measured: Maximum, 12.3 cfs (5,520 gpm), 11/08/72
Minimum, 3.7 cfs (1,660 gpm), 5/18/73

Summary of discharge measurements:

Date	Discharge (cfs)	Discharge (gpm)
09/26/72	8.8	3,950
11/08/72	12.3	5,520
03/25/73	5.1	2,290
04/19/73	3.8	1,700
05/18/73	3.7	1,660
06/14/73	6.3	2,830
07/13/73	7.3	3,280
08/13/73	7.4	3,320
08/24/73	8.9	4,000
09/10/73	8.0	3,590
09/19/73	9.4	4,220
10/02/73	9.7	4,360

[a] Measured 1959-1973 by Alaska Department of Fish and Game; 1976-1983 by U.S. Geological Survey.

[b] All measurements by Alaska Department of Fish and Game.

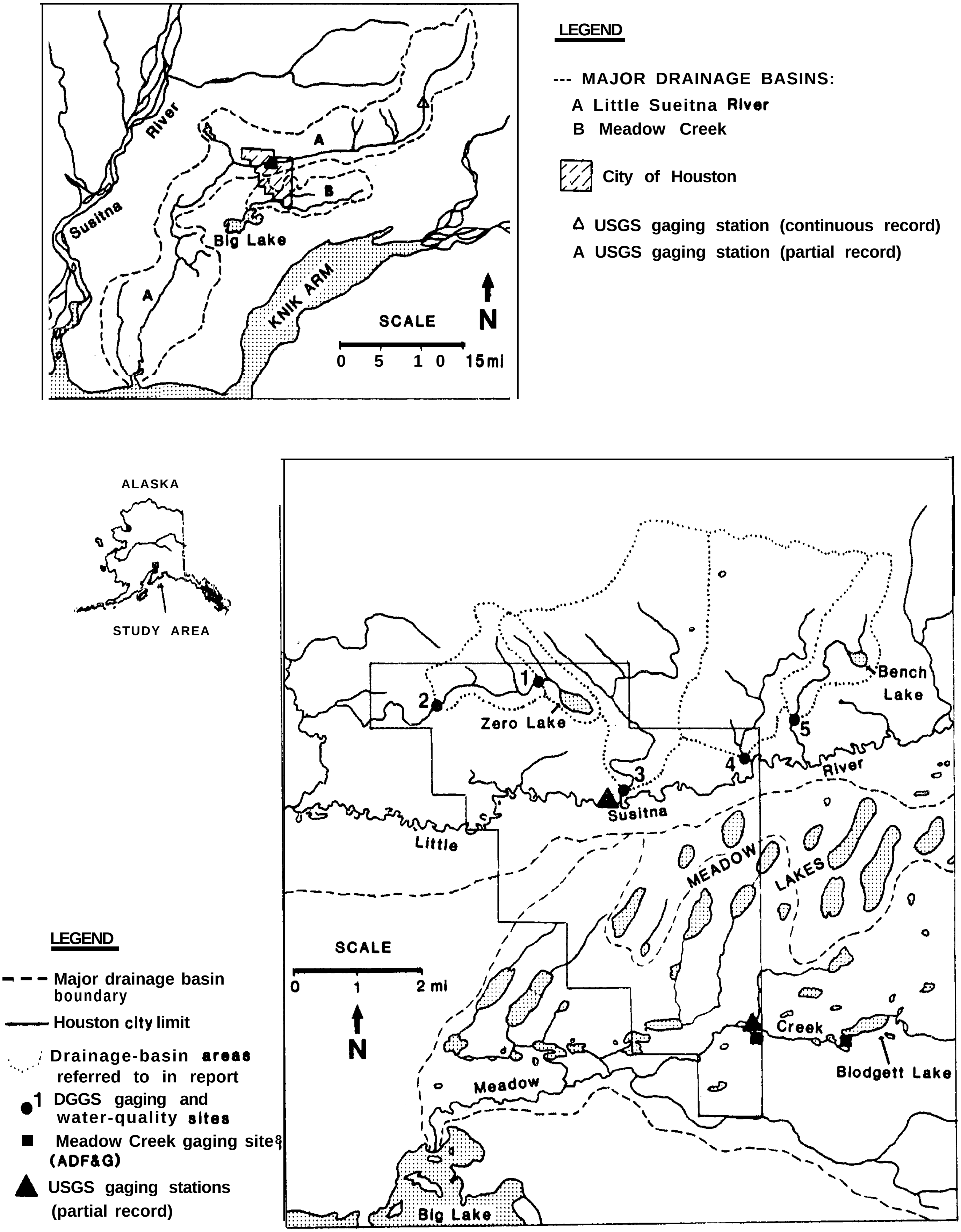


Figure 3. Major drainage basin, data-collection site, and sub-basin location map, Houston, Alaska.

and maximum depth, and mean and maximum velocity for the five sites are shown in table 3, with approximate drainage-basin area and unit runoff values. The data suggest a marked seasonal fluctuation in basin water yields, with winter values near zero.

Data presented in table 3 are probably representative of summer and winter flows that can be expected in these streams; however, absence of a continuous records precludes interpretation over the long term. For instance, site 3 streamflow measurements show large fluctuations, probably from precipitation at the headwaters, and other streamflow measurements may be similarly affected. An expanded study of surface-water supply has been proposed which would utilize stream stage recorders (devices which continuously record the height of the stream's water surface above an established datum plane) installed on streams of primary interest. This would allow closer monitoring of streamflow fluctuations.

To gain a rough idea of peak flows that may be encountered on streams for which no continuous flow record exists, Lamke (1979) developed a set of multiple-regression equations based on data from gaged basins in Alaska. These equations related the magnitude of a discharge with a given frequency to climatic and physical characteristics of a stream's drainage basin: land area, forested land, lake storage, annual precipitation and mean minimum January temperature. Equations for estimating 1.25-, 2-, 5-, 10-, 25-, and 50-yr flood magnitudes are included in Lamke's study. (A 2-yr flood has a 50 percent chance of being exceeded in a particular year, whereas a 50-yr flood has a 2 percent change of being exceeded.) The 2-yr flood peak is generally regarded as corresponding to bankfull stage, or the stage at which a stream first begins to overflow its natural banks (Parks and Lamke, 1984; Langbein and Iseri, 1960). Results from application of these equations to Houston area streams are given in table 4, along with values used for the variables in the equations. These were taken from Lamke's maps and estimated from visual and planimetric analysis of topographic maps, orthophotomaps and aerial photographs, Results from this method, while producing the most reasonable values of several methods tried, should be considered rough estimates only.

Three of the five streams measured in the initial reconnaissance were selected for stage-discharge analysis. Staff gages were installed at sites 2, 3, and 5. These graduated posts enable a person to note the stream stage (the height of the stream's water surface above an established datum plane) each time a discharge measurement is made. (It is important to note that the stage reading is based on an arbitrary datum plane and, thus, is not a measurement of stream depth.) After obtaining several measurements at varying stages and discharges, a rating curve can be plotted and discharge computed for any given stage on that stream (Herschy, 1985). The wider the range of observations, the greater the degree of accuracy achieved. In this case, additional measurements would be desirable during high flow (for instance, after a significant storm event). Figure 4, 5 and 6 present summaries of measurements made at sites 2, 3, and 5 during this study and graphs of the stage-discharge relation for each of the three streams.

Table 3. Summary of observed data[a], Houston area small stream reconnaissance.

Date	Time	Width (ft)	Area (ft^2)	Mean depth (ft)	Maximum depth (ft)	Mean velocity (ft/sec)	Maximum velocity (ft/sec)	Discharge (cfs)	Discharge (gpm)	Drainage area (mi^2)	Unit runoff (cfs/mi^2)	Bed material
Site 1 - Unnamed stream 1/4 mi below Zero Lake outlet												
07/10/85	0945	1.6	0.9	0.5	0.7	0.2	0.3	0.2	90	0.9	0.22	silt
08/22/85	1320	2.8	4.1	1.3	1.9	0.3	0.7	1.4	629	0.9	1.56	
Site 2 - Unnamed stream, mi 60.1 Parks Highway												
07/10/85	1450	3.6	2.1	0.5	0.9	0.5	1.7	1.3	584	2.2	0.59	gravel,
08/22/85	1500	3.5	2.1	0.6	0.8	0.7	2.0	1.6	718	2.2	0.73	sand
03/18/86	1130	3.9	1.8	0.4	0.7	0.4	1.1	0.8	359	2.2	0.36	
Site 3 - Unnamed stream, mi 0.8 Armstrong Road												
07/17/85	1530	6.0	2.4	0.4	0.7	0.7	1.6	2.4	1,080	6.4	0.38	cobbles,
08/22/85	1530	14.5	14.8	1.0	1.5	1.9	4.1	40.8	18,300	6.4	6.38	gravel
02/18/86	1440	-						0.0	0	6.4	0.00	
Site 4 - Unnamed stream, mi 2.8 Armstrong Road												
07/17/85	1430	8.5	10.1	1.1	2.2	0.2	0.4	2.3	1,030	5.2	0.44	silt,
03/18/86	1300	7.5	6.1	0.7	1.2	0.1	0.1	0.6	269	5.2	0.12	clay
Site 5 - Unnamed stream, Bench Lake trail crossing												
07/17/85	1415	4.0(E)	2.0(E)	-	-	0.8(E)		1.6(E)	718(E)	1.9	0.85(E)	silt
02/12/86	1320	-						0.0(E)	0(E)	1.9	0.00(E)	

[a]Values marked (E) are estimated.

Table 4. Estimated flood magnitudes for streams in the Houston area (based on methods in Lamke, 1979).

Site	Drainage basin characteristics: Area (mi^2)	Mean annual precip. (in.)	Mean minimum January temp. (°F)	Area of basin forested (%)	Area of basin lakes (%)	Predicted flood: 1.25-year flood (cfs)	1.25-year flood (gpm)	P-year flood (cfs)	P-year flood (gpm)	S-year flood (cfs)	S-year flood (gpm)	lo-year flood (cfs)	lo-year flood (gpm)	25-year flood (cfs)	25-year flood (gpm)	50-year flood (cfs)	50-year flood (gpm)
1. Unnamed stream 1/4 mi below Zero Lake outlet	0.9[a]																
2. Unnamed stream, mi. 60.1 Parks Highway	2.2	20	4	90	5	8	3,590	16	7,180	28	12,600	39	17,500	48	21,600	67	30,100
3. Unnamed stream, mi. 0.8 Armstrong Road	6.4	20	4	85	0	33	14,800	60	26,900	102	45,800	137	61,500	168	75,400	225	101,008
4. Unnamed stream, mi. 2.8 Armstrong Road	5.2	20	4	90	0	27	12,100	49	22,000	85	38,200	114	51,200	140	62,900	189	84,900
5. Unnamed stream, Bench Lake Trail crossing	1.9	20	4	85	3	8	3,590	15	6,740	27	12,100	37	16,600	47	21,100	65	29,200

[a] Drainage area values for site 1 are included in the values for site 2, because method is not recommended for basins <1 mi^2.

WATER QUALITY

Streams

Water quality measurements were taken in the five Little Susitna River tributaries described in the preceding section. Locations of sampling sites are shown in figure 3. Water temperature, dissolved oxygen concentrations, and specific conductance were measured at each site with a Model 4041 Hydrolab. Stream pH was determined in the field with an Orion pH meter. A Hach Portalab Turbidimeter (Model 16800) was used to measure turbidity in the field.

Table 5 presents results of field measurements of surface-water quality at sites 1, 3, 4, and 5. Water quality at these sites was characterized by high dissolved oxygen concentrations in summer, neutral or slightly acid pH, and relatively low specific conductances, ranging from 34 to 108 μmhos/cm. The high specific conductance of 322 μmhos/cm and low dissolved oxygen concentration measured at site 4 during March indicates ground-water seepage, not surface flow.

Water quality at site 2 was consistently very high. Dissolved oxygen concentrations were near saturation, and pH indicated slight acidity. Specific conductances ranged from 88 to 116 μmhos/cm. The water was clear and ice-free throughout the sampling period.

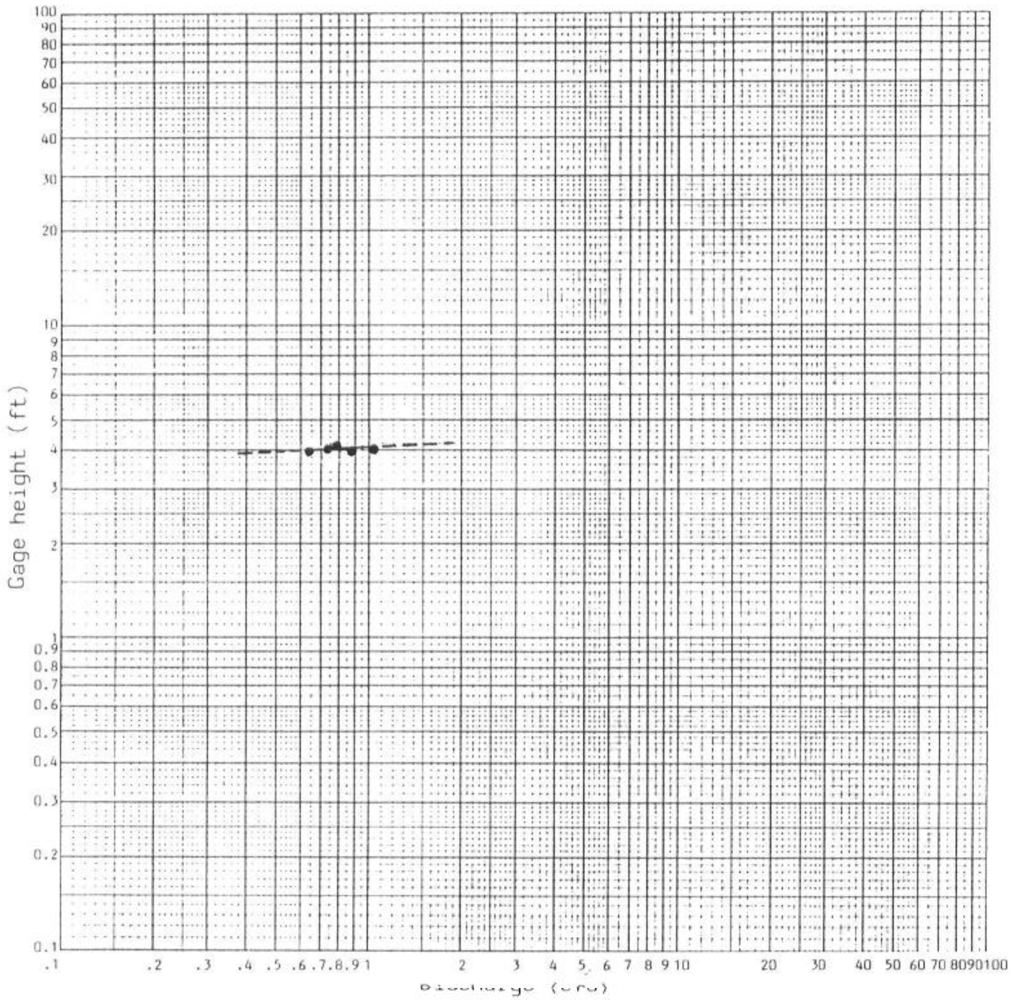
There was a noticeable difference in specific conductance and water temperature between sites 1 and 2 even though they were located on the same stream. On August 22, 1986, Site 1 had low specific conductance (43 μmhos/cm) and a water temperature of 8.4°C, while site 2, located approximately 3 mi downstream, had a higher specific conductance (116 μmhos/cm) and a lower temperature (4.2°C). Also, flow did not increase appreciably between the two sites on that date (table 3). One possible explanation is that streamflow below site 1 is lost to streambed infiltration and is replaced by or reappears as spring flow upstream of site 2. This explanation is supported by the statement in Lebida (1983) that the stream flows underground for considerable distances in certain areas downstream of Zero Lake.

Although suspended-sediment concentrations were not measured, all sites appeared to have low suspended-sediment concentrations during the summer months. Turbid water (20 NTU) was measured at site 3 during high stream flow on August 22, 1985, presumably the result of a storm in the headwaters. It appeared that most of the turbidity was due not to inorganic silt but to very fine organic matter and iron hydroxide precipitate which gave the water a reddish-brown color. The organic matter and iron hydroxide precipitate probably came from wetlands immediately upstream of site 3.

Lakes

Water quality was surveyed on August 22, 1985 in Zero Lake, and on February 12, 1986 in Zero Lake and Bench Lake. Zero Lake has a maximum depth of 32 ft, a mean depth of 11 ft, and a volume of 859 acre-ft (Lebida, 1983). Bench Lake has a maximum depth of 13 ft, a mean depth of 5 ft, and a volume

(a) UNNAMED STREAM AT MI 60.1 PARKS HIGHWAY [Site 2]

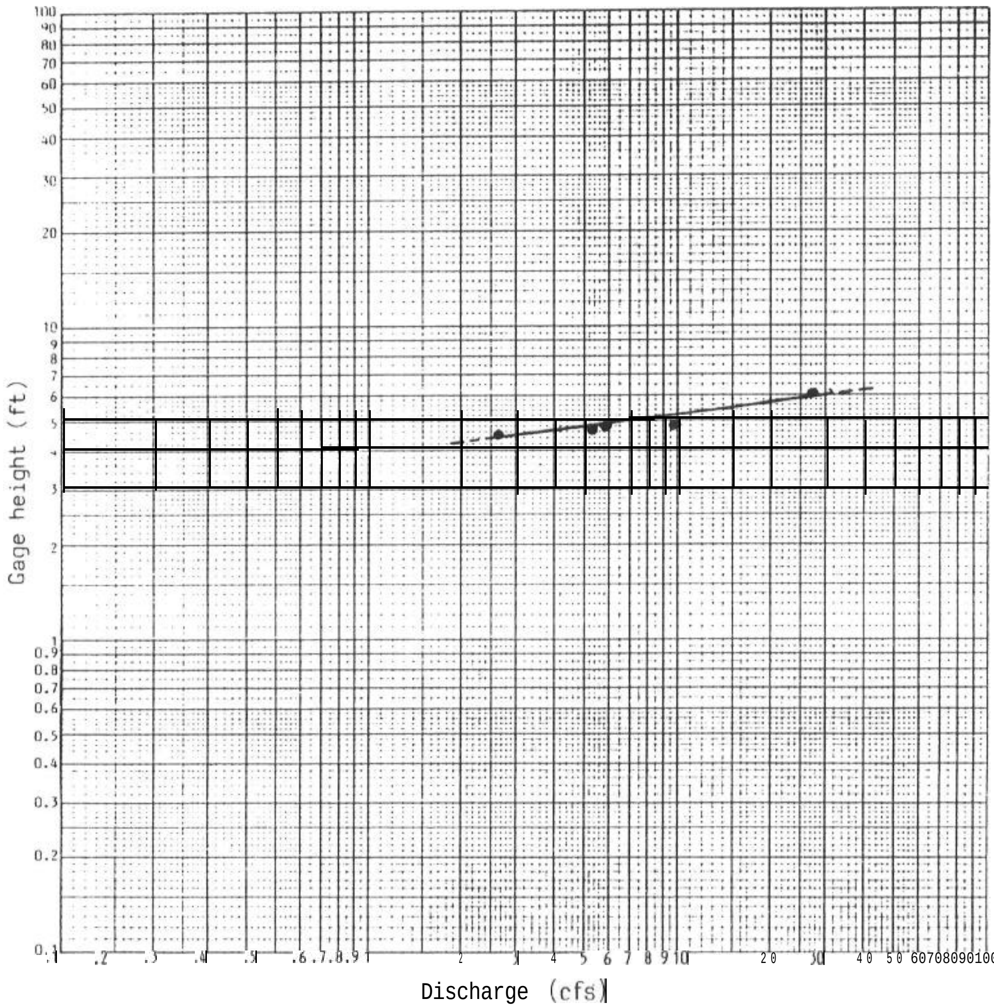


SUMMARY OF MEASUREMENTS

Date	Time	Gage height (ft)	Discharge (cfs)
5/12/86	1140	4.02	1.03
5/28/86	1015	3.99	0.88
6/10/86	1000	3.98	0.64
7/16/86	0930	4.00	0.73
7/21/86	1105	4.01	0.78

Figure 4. Rating curve for unnamed stream at Mile 60.1 Parks Highway (site 2), Houston area, Alaska.

(b) UNNAMED STREAM, MI 0.8 ARMSTRONG ROAD [Site 3]

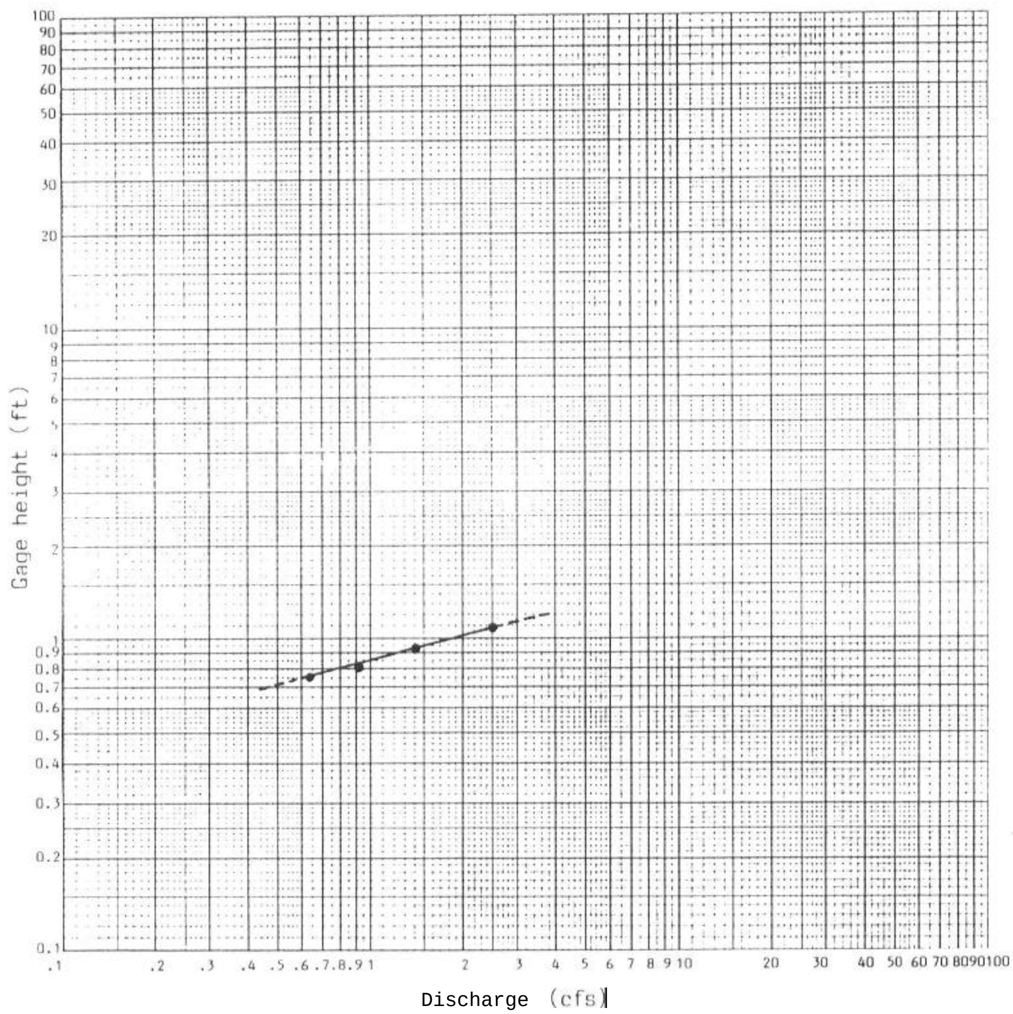


SUMMARY OF MEASUREMENTS

Date	Time	Gage height (ft)	Discharge (cfs)
5/12/86	1250	4.80	9.80
5/28/86	1100	4.68	5.32
6/10/86	1030	4.50	2.65
7/16/86	1015	4.70	5.70
7/21/86	1125	6.07	27.38

Figure 5. Rating curve for unnamed stream at Mile 0.8 Armstrong Road (site 3), Houston area, Alaska.

(c) UNNAMED STREAM AT BENCH LAKE TRAIL CROSSING [Site 5]



SUMMARY OF MEASUREMENTS

Date	Time	Gage height (ft)	Discharge (cfs)
5/12/86	1430	1.08	2.50
5/28/86	1220	0.93	1.41
6/10/86	1130	0.76	0.64
7/16/86	1120	0.80	0.92

Figure 6. Rating curve for unnamed stream at Bench Lake Trail Crossing (site 5), Houston area, Alaska.

Table 5. Water quality variables at stream sites, City of Houston, Alaska, 1985-86.

Site	Date	Water temperature (°C)	Specific conductance (μmhos)	pH (units)	Oxygen, dissolved (μg/L)	Oxygen, dissolved (percent saturation)	Turbidity (NTU)
1. Unnamed stream 1/4 mile below Zero Lake outlet	07-10-85	9.0	34	6.60	--	--	--
	08-22-85	8.4	43	7.10	9.2	79	--
2. Unnamed stream, mi. 60.1 Parks Highway	07-10-85	5.0	--	6.50	--	--	--
	08-22-85	4.2	116	6.95	12.8	98	--
	03-18-86	1.3	99	6.31	13.6	97	--
	05-12-86	3.0	88	6.40	12.6	95	--
3. Unnamed stream, mi. 0.8 Armstrong Road	07-17-85	14.0	--	6.95	--	--	--
	08-22-85	8.0	94	6.95	11.8	100	20
	03-18-86[b]	--	--	--	--	--	--
	05-12-86	0.2	108	6.05	14.2	99	--
4. Unnamed stream, mi. 28 Armstrong Road	07-17-85	9.5	--[a]	6.85	--	--	--
	03-18-86	0	322	7.00	3.6	25	--
5. Unnamed stream, Bench Lake trail crossing	05-12-86	0	82	6.35	14.6	100	--

[a] Equipment malfunction.
[b] Stream frozen to bottom.
-- not determined.

of 172 acre-ft (Lebida, 1983) A staff gage installed in Zero Lake in August to monitor lake level read 2.34 ft on August 22, 1985.

Depth profiles of temperature, pH, specific conductance, and dissolved oxygen concentrations were taken every 1.64 ft (0.5 m) with a model 4041 Hydrolab. Alkalinity in Zero Lake was determined in the field by the titration method (U.S. Environmental Protection Agency, 1983). A Secchi disk was used to measure water column transparency. A Van Dorn water bottle was used to collect point samples for major ions, trace metals, and coliform bacteria at 1.6 and 27.9 ft in Zero Lake in August 1985. Immediately after collection, samples for dissolved ion analysis were filtered through a 0.45 mm membrane filter. Samples for recoverable metal analysis were acidified with concentrated nitric acid. Coliform bacteria samples were analyzed at Chemical and Geological Laboratories of Alaska in Anchorage. Major ion and trace metal samples were analyzed at the Division of Geological and Geophysical Surveys laboratory in Fairbanks, Alaska.

Water quality in Zero Lake was characterized by relatively high dissolved oxygen concentrations and low ionic concentrations. Alkalinity was very low, indicating poor acid neutralizing capability in lake waters. Secchi disk transparency in August was 13.8 ft, an indication of an oligotrophic (nutrient-poor) lake (Taylor and others, 1980). There was also no defined thermocline in August; the lake probably had already "turned over," that is, completely mixed as a result of cooling. Mixing and thermal stratification are important lake processes because they affect the circulation of nutrients, dissolved minerals, and gases which are utilized by algae and aquatic vascular plants.

Major ion concentrations were low in Zero Lake and did not vary significantly with depth (table 6). Trace metal concentrations were also low, but several varied with lake depth. Aluminum and zinc concentrations were higher near surface, possibly due to settling of wind-blown soils. Iron and manganese levels were high near lake bottom as these constituents migrated from lake sediments to the water column under near-anoxic conditions.

The total coliform bacteria count of 152 colonies per 100 ml in Zero Lake indicated that there was a moderate amount of bacterial activity associated with natural decomposition processes in the water column. The fecal coliform bacteria count of 0 colonies per 100 ml indicated that there was no fecal pollution in the lake (table 6).

The winter depth profile at Bench Lake showed low dissolved oxygen concentrations near lake bottom, presumably from aquatic plant decomposition (table 7). Specific conductance values were higher in Bench Lake than in Zero Lake, which indicates that dissolved ion concentrations are higher in Bench Lake, and low dissolved oxygen concentrations indicated poor water quality in Bench Lake during the winter.

SUMMARY AND CONCLUSIONS

The most obvious source of fresh surface water in the Houston area is the Little Susitna River. It is nearby, has a dependable flow, and generally satisfactory chemical quality. However, multiple uses and demands upon this river may make its utilization for a city water supply impractical. The same is true for Meadow Creek, the next largest stream.

Of the minor streams investigated, sites 2 and 3 showed the greatest potential for water supply. Site 3 had the greatest flow measured (40.8 cfs or 18,300 gpm) (table 3). However, this stream showed the widest fluctuations in streamflow and appeared to have frozen to the bottom in March 1986. In addition, high flow was accompanied by high turbidity from what appeared to be fine organic matter and iron hydroxide precipitate originating in wetlands upstream. Site 2 had the most consistent flow, characterized by clear, ice-free, high-quality water encountered on each visit. Quantity of water in this stream, however, may be inadequate for the city's requirements. Further analysis by stream stage recorder would provide more complete data about water supply.

Table 6. Water quality variables for Zero Lake, Houston, Alaska, August 22, 1985, 1330 Alaska daylight time.

Sampling depth (ft)	Water temperature (°C)	Specific conductance (μmhos)	pH (units)	Oxygen, dissolved (mg/L)	Oxygen dissolved (percent saturation)	Alkalinity, bicarbonate (mg/L)
1.6	14.4	25	8.2	10.8	100	--
3.3	14.4	24	8.0	10.8	100	11.0
4.9	14.5	24	8.1	10.5	100	--
6.6	14.4	24	8.0	10.5	100	--
8.2	14.5	24	8.0	10.3	100	--
9.8	14.5	23	7.9	10.6	100	--
11.5	14.4	23	7.9	10.4	100	--
13.1	14.4	23	7.9	10.4	100	--
14.8	14.4	24	7.9	10.4	100	--
16.4	14.4	23	7.9	10.4	100	--
18.0	14.4	23	7.8	10.3	100	--
19.7	14.4	22	7.8	10.3	100	--
21.3	14.4	22	7.8	10.5	100	--
23.0	14.4	22	7.8	10.2	100	--
24.6	14.3	22	7.8	10.2	100	--
26.2	14.2	22	7.8	10.0	98	--
27.9	12.1	24	7.2	5.7	53	12.0
29.5	11.6	28	6.9	2.0	18	--
31.2	11.1	38	7.0	1.6	15	--
32.8	10.7	76	6.8	1.4	13	--

Sampling depth (ft)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)
1.6	0.25	0.75	1.27	0.21	0.06	1.54	0.037
27.9	0.26	0.75	1.58	0.38	0.08	1.17	0.023

Sampling depth (ft)	Aluminum, total recoverable (μg/L)	Arsenic, total (μg/L)	Boron, dissolved (μg/L)	Iron, total recoverable (μg/L)	Manganese, total recoverable (μg/L)	Zinc, total recoverable (μg/L)	Coliform, total (cols/100 ml)	Coliform, fecal (cols/100 ml)
1.6	121	1.9	35	65	6	126	152	0
27.9	53	2.3	36	198	21	40		

Secchi disk transparency (ft)
13.8

Table 7. Water quality variables for Zero and Bench Lakes, Houston, Alaska, February 12,1986.

Time: 1035 Alaska standard time.
Ice thickness: 2.4 ft.
Snow depths: 0 ft.

Zero Lake

Sampling depth[a] (ft)	Water temper-ature (°C)	Specific conductance (μmhos)	pH (units)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)
0.3	0.4	27	7.2	16.1	111
1.6	2.3	24	7.6	14.5	105
3.3	3.1	24	7.5	12.8	95
4.9	3.4	23	7.5	12.3	92
6.6	3.5	23	7.4	12.4	93
8.2	3.6	23	7.4	12.2	92
9.8	3.5	23	7.4	12.3	92
11.5	3.5	23	7.4	12.4	93
13.1	3.6	23	7.4	11.4	86
14.8	3.6	22	7.3	11.3	85
16.4	3.8	23	7.3	8.5	64
18.0	3.8	23	7.2	8.3	62
19.7	3.8	23	7.1	7.8	59
21.3	3.9	23	7.1	6.3	48
23.0	3.9	23	7.0	5.4	41
24.6	4.0	25	6.9	3.9	30
26.2	4.1	26	6.9	2.6	20
27.9	4.4	38	6.8	1.6	12

Time: 1330 Alaska standard time.
Ice thickness: 2.4 ft.
Snow depth: 0 ft.

Bench Lake

Sampling depth[a] (ft)	Water temper-ature (°C)	Specific conductance (mmhos)	pH (units)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent, saturation)
0.3	1.0	105	6.8	8.9	63
1.6	1.8	105	6.9	6.5	47
3.3	2.5	105	6.9	4.9	36
4.9	3.0	107	6.9	2.7	20
6.6	3.6	110	6.9	2.0	15

a Sampling depths are measured from bottom of ice.

Site 4, having a slightly smaller drainage area than site 3, may exhibit similar streamflow characteristics, but site 4 was not measured during site 3's high-flow period. However, measurable flow occurred in mid-March (table 3), and site 4 might be considered as an alternative if other sites proved impractical. Sites 1 and 5, having the smallest drainage areas, low flows and seasonal freezing, appear to be the least likely prospects of the five sites, on the basis of data collected.

Data collected at Zero Lake indicated good water quality and no fecal pollution. Its volume is five times greater than that of Bench Lake, which had poor water quality when sampled in February 1986. On the basis of data collected, Zero Lake shows greater water-supply potential than Bench Lake.

REFERENCES CITED

Bigelow, B.B., Lamke, R.D., Still, P.J., Van Maanen, J.L., and Vaill, J.E., 1985, Water resources data, Alaska, water year 1984: U.S. Geological Survey Water-Data Report AK-84-1, 350 p.

Herschy, R.W., 1985, Streamflow measurement: London, England, Elsevier Applied Science Publishers Ltd., 553 p.

Lamke, R.D., 1979, Flood characteristics of Alaskan streams: U.S. Geological Survey Water-Resources Investigations Report 78-129, 61 p.

Langbein, W.B., and Iseri, K.T., 1960, General introduction and hydrologic definitions, manual of hydrology: Part 1, General surface-water techniques: U.S. Geological Survey Water-supply Paper 1541-A, 29 p.

Lebida, R.C., 1983, Upper Cook Inlet coho salmon habitat evaluations, 1979-1981: Alaska Department of Fish and Game Division of Fisheries Rehabilitation, Enhancement, and Development, Report no. 8, April 1983, 73 p.

Parks, B., and Lamke, R.D., 1984, Estimating peak flows from channel widths in Alaska: in Alaska's water: a critical resource: Fairbanks, Alaska, University of Alaska Institute of Water Resources, Report IWR-106, November 1984, p. 107-122.

Reger, R.D., and Updike, R.G., 1983, Upper Cook Inlet region and the Matanuska Valley: in Richardson and Glenn Highways, guidebook to permafrost and Quaternary geology, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, Guidebook 1, p. 185-259.

Taylor, W.D.,, Lambou, V.W., Williams, L.R., and Hern, S.C., 1980, Trophic state of lakes and reservoirs: U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Technical Report E-80-3, 30 p.

U.S. Environmental Protection Agency, 1983, Methods for Chemical Analysis of Water and Wastes: U.S. Environmental Protection Agency, EPA-600/4-79-020.